

From the Authors -

ON THE

NOMENCLATURE OF THE FORAMINIFERA.

BY

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Part III.—*The Species enumerated by Von Fichtel and Von Moll.*

THE work we have now to treat of has been already incidentally noticed in our former papers. It is entitled :—

“Testacea Microscopica aliaque minuta ex generibus Argonauta et Nautilus ad naturam delineata et descripta a Leopoldo a Fichtel et Jo. Paulo Carolo a Moll. Cum 24 Tabulis æri incisis.”

(“Microscopische und andere kleine Schalthiere aus den Geschlechtern Argonaute und Schiffer, nach der Natur gezeichnet und beschrieben von Leopold von Fichtel (Mitglied der Linneischer Gesellschaft zu London, und der Asiatischen zu Calcutta), und Joh. Paul Carl von Moll. Mit 24 Kupfertafeln. 4to. Wien, 1803.”)

In the works of Walker and Montagu previously noticed by us*, we have had to do with, for the most part, dwarfish forms belonging to northern habitats; and hence many of them have had to be ranked as varieties, of but secondary value zoologically. In the Linneæan list of *Foraminifera* (see our paper in the Ann. Nat. Hist. 3 ser. vol. iii. p. 474, &c.) there are several typical forms, which attracted the attention of the older naturalists; but in the work before us we have a fine, though incomplete, series of large, well-grown, specific types, which have been the source of numerous quasi-generic and pseudo-specific distinctions in the works of later authors. These writers have been guided by the false analogy of Molluscan types, which, however, have nothing in common with Rhizopodous shells, except similarity of form, or isomorphism; and it was not until naturalists recognized the really low grade of the *Foraminifera*, as demonstrated by Dujardin (1835) with respect to several of their forms, that their classification was seen to be dependent upon a wide range of variation within specific limits, such as one again finds only in the lower members of the vegetable kingdom.

Fichtel and Moll, in their Preface, give a rapid glance at what had been already effected in the working out of the *Foraminifera*, and express their dissatisfaction with the result. The microscopical Nautiloid shells chosen by them for description are not,

* Ann. Nat. Hist. ser. 3. vol. iv. p. 333, &c.

as a whole, illustrative of any particular fauna; but most of them are Mediterranean forms, either recent, or fossil from deposits belonging to the Mediterranean area, namely Tuscany and, in a few instances, the Austro-Hungarian district. The remainder were derived from the Red Sea.

As the specimens selected for illustration represent only one section or "genus" in the nomenclature used by these authors, namely that which they termed "Nautilus," and as they intended to have figured and described (had the work paid its expenses) others of the sections proposed by them to constitute their genera "Hammonium," "Lituus," and "Orthoceras," a more complete illustration of the Mediterranean fauna, with specimens from other localities, would probably have been made, had their work been completed.

Impressed with the difficulty of defining species, these authors appear to have seized upon certain well-marked and, as a rule, large forms for description; and in some degree they were evidently led towards a conception of the true characters of a Rhizopodous species, as far as the Cristellarian forms are concerned; still they were so far trammelled with the notion of the Cephalopodous nature of these little shells, that they left the subject almost as they found it, except having put forward the important recognition of the often doubtful value of mere surface-marking and of outline in the characterization of the species. Their careful descriptions, however, and their well-drawn and neatly coloured figures mark an epoch in the bibliographical history of *Foraminifera*. Montagu, in our own country, at the same period was also bestowing care and taste on the description and figuring of these little shells; but his work had not reached Vienna.

In the following Table we have arranged, according to their relations, the Rhizopodous shells figured and described by Fichtel and Moll; and we may remark here, as we have elsewhere, that it is not to confuse the student that we so freely group together under a few specific names the varieties that have received so many distinctive appellations, but to assist in the elucidation of the exact relationship of the several forms; so that, instead of separate and unintelligible atoms, to be classed only according to their shape and size, the *Foraminifera* may be ultimately seen to fall into natural groups intimately related and at once carrying their meaning, physiologically and zoologically, to the educated eye. We have many collaborators in this pleasing task, at home and abroad,—some strong in long experience of these protean animalcules, some powerful with the microscope to unravel their tissue, some bringing a rich knowledge of other forms of life to the work. We gladly contribute the result of our own gatherings in these several branches of research, and firmly

1. POLYSTOMELLA (Nonionina) asterizans.	A Nonionine subspecies of POLYSTOMELLA : type, P. CRISPA. [The varieties appear in Italics.]
2. ————— <i>incrassata</i> .	
3. ————— <i>pompilioides</i> .	
4. ————— <i>Scapha</i>	
5. ————— <i>Fuba</i>	
6. ————— <i>striatopunctata</i> .	
7. ————— <i>ambigua</i> .	
8. ————— <i>macella</i> .	
9. ————— <i>strigilata</i> .	
10. ————— CRISPA (Linn.)	
11. ————— <i>craticulata</i> .	
12. NUMMULINA radiata	The typical species of the genus POLYSTOMELLA. } Small varieties of N. PLANULATA. } Probably varieties of N. PLANULATA. "N. lenticularis, γ," may possibly be } a variety of N. LÆVIGATA. C. Calcar stands in the relation of a subspecies to NODOSARINA RAPHANUS. For the sake of binomial convenience, Cristellaria is retained as a subgeneric term, of equal value to Nodosaria.
13. ————— <i>venosa</i>	
14. ————— <i>Mamilla</i>	
15. ————— <i>lenticularis</i> , α, β, γ, δ, ε	
16. Cristellaria Calcar (Linn.)	
17. ————— <i>papillosa</i> .	
18. ————— <i>Vortex</i> .	
19. ————— <i>costata</i> .	
20. ————— <i>acutauricularis</i> .	
21. ————— <i>Crepidula</i> .	
22. ————— <i>Cassid.</i>	
23. ————— <i>Galea</i> .	This is a good species of a subgenus of ROTALIA. A typically specific form of a genus.
24. CALCARINA SPENGLERI (Gmel.)	
25. ROTALIA REPANDA	
26. ————— <i>sinuata</i> .	
27. ————— <i>Auricula</i> .	A typical species of a subgenus of ROTALIA.
28. PLANORBULINA FARCTA.....	
29. ————— <i>tuberosa</i> .	
30. PENEROPLIS PLANATUS	
31. ORBICULINA ADUNCA	A good species, belonging to a well-marked genus. A specific type of an accepted genus.
32. ————— <i>Orbiculus</i> .	
33. ————— <i>angulatus</i> .	
34. ALVEOLINA MELO	Generic and specific.

believe that ultimately, with conscientious labour, and free expression of independent opinions, the Rhizopodists will arrive at the hoped-for result of placing these *Microzoa* on as good a basis of classification as that on which many of the higher groups of animals now rest. We may repeat, too, that the varietal names already established are not by any means thrown aside by us in general use, unless they are in duplicate, or otherwise quite unnecessary; but that these, and as many more as it may be requisite to propose, must be used in descriptions and comparisons—their really slight zoological value being always kept in mind.

1. *Nautilus asterizans*. Page 37, pl. 3. figs. *e-h*. "Recent: Zoophytic concretions*, Mediterranean." This is a *Nonionina*, small, many-chambered, and Nautiloid; it has a slight umbilicus, around which an exogenous growth of shell-matter radiates along the concave septal lines to about one-half their length. It inhabits sandy shores and estuaries, and is common, in its many varieties, both in the fossil and the recent state. This is one of the typical forms of *Nonioninae* (which, after all, are but low forms of *Polystomella*). It exhibits the chief features which are seen in different degrees of development in other related forms. Its astral limbation is a feature which is much exaggerated in *N. limba*, D'Orb. (Modèles, No. 11), and curiously modified with flaps in *N. stellifera*, D'Orb. (Foram. Canaries, pl. 3. figs. 1, 2). The figure in Soldani's 'Testaceograph.' referred to by Fichtel and Moll with some doubt, as equivalent to *N. asterizans*, is clearly not related.

2. *Nautilus incrassatus*. Page 38, pl. 4. figs. *a-c*. "Recent: Portoferraio, Isle of Elba, Mediterranean." An umbonate variety of *Nonionina asterizans*; it has deeply sulcate septal lines, and is more rounded at its periphery than the foregoing, from which also it generally differs in having a closer texture with finer pores. Many of the forms of *Nonioninae* which have received specific appellations exhibit considerable variableness in the size of the perforations of their shells. *N. incrassata*, F. & M., and *N. Scapha*, F. & M., have usually the finest, *N. granosa*, D'Orb. and *N. perforata*, D'Orb., the coarsest pores.

N. incrassata lives, with other varieties of *N. asterizans*, in the shallow waters of the Mediterranean; it occurs fossil at Grignon, and is the same as *N. lavis*, D'Orb. (Modèles, No. 42), fossil from Bordeaux. The umbo, in some of the astral forms, is represented by granules, as in *N. tuberculata*, D'Orb. (For. Foss. Vien. pl. 5. figs. 13, 14).

* In the shelly deposits of the Mediterranean, and at the base of coral-reefs, we find such concreted masses of broken shells, Bryozoa, Nullipores, &c., as are here doubtlessly referred to.

A small delicate variety of *N. asterizans* (from Cuxhaven), intermediate between *N. depressula* and *N. crassula* of Walker, is accurately figured, with the colours of nature, by Prof. Ehrenberg, in the 'Abhandl. Akad. Berlin, 1839' (1841), pl. 2, figs. 1 a-1 g. It is here termed "*N. Germanica*."

3. *Nautilus pompilioides*. Page 31, pl. 2, figs. a-c. "Recent : zoophytic concretions, Mediterranean. Fossil : Coroncina, Tuscany." A small, common, Nautiloid *Nonionina*. Subglobose, with flush cells, which are not so numerous as in *N. asterizans*, umbilicate, smooth, intermediate as to the size of its perforations between *N. incrassata* and *N. granosa*. This is one of the subglobose varieties of a subspecies, the peculiar features of which are best represented by *Nonionina asterizans*. The *N. umbilicata* of D'Orbigny's 'Modèles' (No. 86) and *N. Soldanii*, D'Orb. (Foram. Foss. Vienne, pl. 5, figs. 15, 16), are closely related varieties. The *N. crassula*, Walker, *N. depressula*, Walker, and *N. umbilicata* of Montagu (not Walker), are also nearly allied, but they are thinner, and have the septal joints more deeply sunken. *N. tuberculata*, *N. perforata*, *N. granosa*, *N. punctata*, *N. communis*, and *N. Boueana* (D'Orb. For. Foss. Vien. pl. 5) are forms akin to *N. Soldanii*, and present varietal conditions of outline, of ornament, and of foramina within the limits of specific latitude.

N. pompilioides is very common fossil in the Subapennine clays, and recent in deep water (especially at from 100 to 500 fathoms) in the Mediterranean and other seas.

N. pompilioides bears the same relation to *N. asterizans* that *Rotalia Soldanii* does to *R. Beccarii*, being a thick form with flush cells, which in shallow water become more outspread with gibbous chambers.

The following references to Soldani's figures by Fichtel and Moll, for this species, are correct : Soldani, Sagg. Oritt. p. 100, pl. 2, fig. 16 *tt*, *TT*, *VV*, *XX*.; Testaceogr. vol. i. p. 59, pl. 46, fig. *qq*.

4. *Nautilus Scapha*. Page 105, pl. 19, figs. *d-f*. "Recent : Adriatic Sea." This is an oblong variety of *Nonionina asterizans*, rapidly increasing in the size of its chambers. It is the *Nonionina communis*, D'Orb. (For. Foss. Vien. pl. 5, figs. 7, 8). This variety is of common occurrence in all seas, and also in the Tertiary deposits.

5. *Nautilus Faba**. Page 103, pl. 19, figs. *a-c*. "Recent : sand from Rimini and other parts of the Adriatic and Mediterranean. Fossil : Sienna, Volterra, and near S. Quirico." This is an interesting variety, showing the first trace of passage between *Nonionina* and *Polystomella*,—further links of union

* This form is not related to the figures referred to in the works of Soldani and Plancus.

being supplied by the next-mentioned variety (*P. striatopunctata*), of which this may be said to be an oblong form. The aperture is here crossed with little bars; and the septal lines also are bridged over in some specimens; both of which features are carried to greater extent in the following varieties. This variety is not common; our best specimens are from the Arctic Seas.

6. *Nautilus striatopunctatus*. Page 61, pl. 9. figs. *a-c*. "Recent: Red Sea*." A smooth round-edged Nonionine shell, variable in its thickness and in the number of bridges over the septal spaces. Its aperture varies from the simple cross-slit to the cribriform plate. Here the Nonionine character is merged in that of *Polystomella*, the septal lines being more or less regularly bridged over, though often so minutely as to escape casual observation. When more developed, these bridgings of the septal lines produce not only linear pits, but sometimes a double row of septal galleries. In the *P. gibba* of Schultze the septal bridges are well developed, and a further growth of exogenous matter takes place over the whole shell, in the form of elegant sinuous patches of transparent calcareous granulations. A still greater modification of the surface obtains in *Polystomella crispa* and its allies, presently to be noticed.

P. striatopunctata sometimes has the simple crescentic aperture of *Nonionina*; but this is often subdivided by calcareous bars, and so becomes the cribriform septal plane of *Polystomella*. It may be either umbilicate or umbonate; and the umbo may be granulated, and so afford a gradation into *Nonionina granosa*, D'Orb.

Polystomella, indeed, is but a more complex form of *Nonionina*. They belong to one generic group; and indeed we seem to have but one, or at most two, species here. Some of the *Nonioninae* (of the *N. sphaeroides* type) are probably of a different specific group. As two subspecies, the *Nonionina asterizans* and *Polystomella crispa* may be retained in nomenclature with advantage—*N. asterizans* being the central form of one, and *P. crispa* that of the other; but *Polystomella* is the true leading form.

Nonionina striatopunctata occurs in shore-sand nearly everywhere, especially in the Arctic Seas, where it attains its greatest size, and is accompanied by *N. Faba*, *N. Scapha*, and *N. stellifera*. It is found fossil in the Upper Tertiaries.

Ehrenberg has well figured, with natural colours, some living specimens of *N. striatopunctata* (under the name of *Geoponus Stella-borealis*), from Cuxhaven, in the 'Abhandl. Akad. Berlin, 1839' (1841), pl. 1. figs. *a-g*.

7. *Nautilus ambiguus*. Page 62, pl. 9. figs. *d-f*. "Recent:

* In sand obtained from large shells, and given to the authors by Spengler.

Red Sea*." This is a somewhat flat *Polystomella*, slightly umbonate, with the septal spaces open, rendering the chambers somewhat vesicular and the outline crenulate. It approaches near to the typical *P. crispa*, and is a common variety. D'Orbigny has figured a similar form under the name of *P. Listeri* (For. Foss. Vien. pl. 6. figs. 19-22).

8. *Nautilus macellus* (two varieties). Page 66, var. α . pl. 10. figs. *e-g*; var. β . pl. 10. figs. *h-k*. "Recent: Zoophytic concretions, Mediterranean." Var. α is a sub-complanate, slightly unsymmetrical *Polystomella*: the unequal development of the two faces is an interesting feature. Var. β is symmetrical, not quite so flat as var. α , and is lobated in its outline by a periodical irregularity of growth, peculiar perhaps to the individual. Both of these are thin varieties of *Polystomella crispa*.

D'Orbigny has recognized the similarity of his *P. Fichteliana* (For. Foss. Vien. p. 125, pl. 6. figs. 7, 8) to *P. macella*,—a similarity too close, in our opinion, to allow of any distinction.

P. macella, when plano-convex, would be equivalent to the *Faujasina carinata*, D'Orb. (For. Foss. Vien. p. 194, pl. 21. figs. 29-31) from the chalk of Maestricht.

This variety and other flat *Polystomellæ* are very common in the shallow waters of the Mediterranean and the tropical seas, and have been washed into the sands from the sea-weeds to which they have been attached by their flattest surface. This face often shows the whole coil of the spire, as in *Faujasina carinata*, D'Orb.

A large symmetrical umbonate variety, near to *P. macella*, var. α , occurs in great abundance in some of the Subapennine and other Tertiary sands and clays.

Polystomella macella is more unsymmetrical than any Operculine variety of Nummulite, but not so much so as is the rule in *Amphistigma vulgaris* (= *A. gibba*): in the latter the aperture is a large slit nearly all on the more bulging side; whilst in *Polystomella macella*, when most twisted in its growth, the septal plane and aperture are but little affected, indeed scarcely more so than in the unequally gibbous *Operculinæ*. Both the symmetrical and unsymmetrical Nautiloid Foraminifers delight in complanate varieties; and these are often the more irregular in their growth because of their weak and starved condition.

The peculiar twist acquired by the complanate *Polystomellæ* is equalled by that in the Australian *Vertebralinæ*, both discoidal and crozier-shaped, which, although showing just the same kinds of variation as they are wont to do in other parts of the world (and in fossil deposits), yet have, one and all, their mouth turned more or less to one side; and in the very flat discoidal varieties the shells are often saddle-shaped.

* In sea-sand from shells, given by Spengler.

Polystomella, in its very small and simple varieties, as well as its very large and complex forms, and also in its often prickly and occasionally strongly spinous varieties, has a peculiar and interesting parallelism with *Rotalia Beccarii*.

9. *Nautilus strigilatus* (two varieties). Page 49, var. α . pl. 5. figs. *c-e*; var. β . pl. 5. figs. *f, g*. "Recent: Povice, near Novi, Austrian shore of the Adriatic." Var. α is a somewhat flattened *P. crista*, with a small umbo, which, however, is relatively larger than in the foregoing varieties. Var. β is a rowelled condition of the same, and is the *P. aculeata*, D'Orb. (For. Foss. Vien. pl. 6. figs. 27, 28). Both are common shallow-water forms. Fichtel and Moll refer correctly to Soldani, Testaceogr. vol. i. p. 54, pl. 34. fig. 1, for this form.

10. *Nautilus crispus*. Page 40, pl. 4. figs. *d-f*. "Recent: Adriatic. Fossil: Etruria." The references to Planus and Soldani for figures of this species are correct: Planus, Conch. p. 10, pl. 1. fig. 2; Soldani, Sagg. Orit. p. 100, pl. 2. fig. 17 *x z*; Testaceogr. vol. i. p. 54, pl. 33. fig. F, and pl. 34. figs. G, H. This is the typical *Polystomella crista*, Linnæus, being an intermediate state of development between that of the thin, flat, depauperated *P. macella* and the very thick, largely umbonate, and frequently gigantic *P. craticulata*. It is of world-wide distribution, and occurs fossil in the Tertiaries. Its relationship to *Nonionina* is alluded to at pages 101 & 103.

11. *Nautilus craticulatus*. Page 51, pl. 5. figs. *h-k*. "Recent: Red Sea. From sea-sand in large shells: given by Spengler."

This is the form of *Polystomella* which attains a very large size among the coral-reefs of Fiji, Red Sea, Australia, and New Zealand, also at the Canaries and the Philippines. In the figure referred to the umbo is drawn large, but frequently we have met with massive individuals, from the Australian reefs, having this central exogenous growth extending over nearly the whole of the shell, small patches only of the septal structure appearing here and there towards the margin. Indeed, this masking of the surface has been erroneously regarded by some as characteristic of a specific difference. Not only in this large *Polystomellous* species, but in many specific groups of Foraminifers, superficial shelly matter may either be wanting or be developed to any extent, without proving essential distinctness.

It occurs fossil in the Miocene Tertiary beds of San Domingo.

12. *Nautilus radiatus*. Page 58, pl. 8. figs. *a-d*. "Recent: Red Sea." In sea-sand from the interior of shells in Spengler's collection.

This is a small, smooth, lenticular *Nummulina*, about 1 line in diameter; marked with twenty-four radiating, translucent, septal lines, slightly sinuous, with an open sigmoid flexure, which extends from the periphery to the umbonal centre, and as

many intermediate short parallel septal lines towards the peripheral margin. These indicate altogether nearly fifty chambers in the outer whorl, the lateral lobes of which, in passing towards the umbonal centre, interfere with each other, leaving only indications of half as many elongate triangular sinuous umbilical lobes.

In the section, fig. *c*, we see four whorls and a round central primordial cell; and the outer whorl has seventeen chambers, narrow from back to front, transversely wide, and obliquely set.

13. *Nautilus venosus*. Page 59, pl. 8. figs. *e-h*. "Recent: Red Sea." From shell-sand sent by Spengler.

A small, smooth, lenticular *Nummulina* (1 line in diameter), marked with twelve translucent, sinuous, radiating septal lines, several of which appear to bifurcate, and some to trifurcate, at their peripheral extremities. These may indicate seventeen chambers of irregular width, the umbilical lobes of which interfere with each other, leaving only about twelve broad triangular lobes on the surface, with small intercalations. In the section, fig. *g*, three and a half whorls and a central cell are seen; the outer whorl is here figured as made up of twelve rhombical chambers.

The only difference between *Nummulina venosa* and *N. radiata* is that in the latter the chambers are relatively larger (twice the size), the segments of sarcode produced at each gemmation having been thicker from back to front than in the former shell. The angle at which the segments are set on is the same in the two shells, and the lobes or flaps laid on the umbilical surfaces have in both the same gentle sinuous form, though in one shell they are of half the size that they are in the other. As the relative size of the segments cannot be accepted as a specific distinction, we do not regard these two *Nummulinæ* as belonging to separate species. Fichtel and Moll themselves had some hesitation in giving them two names.

In Prof. Williamson's *Nummulina planulata*, Monogr. p. 37, pl. 3. figs. 76, 77, we have a similar little shell ($\frac{1}{12} - \frac{1}{16}$ inch in diameter), with straight or rather wavy radii; the umbilical area is left open by the shortened apices of the lateral lobes, so that parts of the former whorls are visible,—a condition retrospective of some *Operculinæ*. Prof. Williamson had his specimens from Portsmouth and Scarborough; and he refers it correctly to the *N. planulata* of Lamarck, more especially to the biconvex variety known as *N. variolaria*, Lam. We have no doubt of this belonging to the same species as the two varieties above mentioned, although the curvature of the septal lines is modified in some of the later chambers, and though there is an umbilical deficiency of shell-matter. From Hund Island, in Davis Strait, we have some small, delicate, recent *Nummulinæ*

(dredged by Dr. P. C. Sutherland, at 25 to 30 fathoms) of the same type as the above, presenting sinuous radial lines of the same pattern as those in *N. radiata*. Recent *Nummulinae* of larger size than any of the foregoing (about $\frac{1}{2}$ inch in diameter) are abundant along the Australian coral-reefs at from 10 to 20 fathoms, as shown by dredgings brought from Australia by Mr. Jukes. These show radiating septal lines of a similar sigmoidal pattern, and thus closely resemble D'Orbigny's *Nummulina radiata** (For. Foss. Vien. p. 115, pl. 5. figs. 23, 24). This Viennese Nummulite D'Orbigny has referred to Fichtel and Moll's *Num. lenticularis*, var. δ , but, we believe, erroneously, as far as varietal relationship is concerned. The Australian *Nummulinae* just mentioned freely pass into *Operculinae*, of a rather larger growth, by the gradual loss of the triangular overlying flaps of sarcode,—gradations being thus made between such a form as that above quoted from Williamson's 'Monograph,' through innumerable and gentle stages, into flat outspread *Operculinae* and *Assilinae*, exposing their bare whorls. In these Australian dredgings the individuals are excessively numerous, in an almost purely calcareous mud, constituting in some instances upwards of fifty per cent. of the deposit. These Foraminifers are accompanied by a great variety of *Orbitolites*, *Alveolinae*, *Polystomellae*, *Miliolae*, *Rotaliae*, &c., mostly of large size. This fauna is strikingly a counterpart of the Calcaire grossier.

14. *Nautilus Mamilla*. Page 53, pl. 6. figs. *a-d*. "Fossil: Brunn near Steinfeld, Neusiedler See, Margareth, Maria Loretto, Kroisbaeh, and other places in Lower Austria and on the confines of Hungary."

A smooth lenticular Nummulite ($1\frac{1}{2}$ line in diameter), with thin edges and a raised umbonal centre on each face. In fig. *c* $5\frac{1}{2}$ whorls are shown, with 24 oblique chambers in the outer whorl; the central cell is small.

Vieomte d'Archiac and M. J. Haime, in their 'Monographie des Nummulites' (contained in their 'Description des Animaux Fossiles du Groupe Nummulitique de l'Inde,' 4to, Paris, 1853), express an opinion that "*Nautilus Mamilla*" is probably *Nummulina Ramondi*, Defr., var. *d* (Monogr. p. 129, pl. 7. figs. 13-17): this may be, though the evidence is not very clear.

15. *Nautilus lenticularis*. Five varieties; p. 55. "Fossil: Klausenberg in Transylvania.

Var. *a*, pl. 6. figs. *e-h*. A small, smooth, thickly lenticular

* MM. d'Archiac and Haime pass over this Nummulite, suggesting that it may be an *Amphistegina* (Monogr. p. 160). It is, however, a true Nummulite in all its characters. We do not know of any bilaterally symmetrical *Amphistegina*.

Nummulite, 2 lines in diameter. The section, fig. *g*, shows three whorls and a large central chamber; eighteen chambers in the outer whorl. The chambers, as to their relative size and setting-on, are like those of *N. Mamilla*.

By MM. d'Archiac and Haime *N. lenticularis*, var. *a*, is recognized as a species, and renamed *N. Tchihatcheffi*, Monogr. p. 98, pl. 1. fig. 9.

Var. β , pl. 7. figs. *a*, *b*. A small lenticular Nummulite, 2 lines in diameter, covered with closely-set granules; on the figure about thirteen granules lie in a row along the diameter of the shell.

According to MM. d'Archiac and Haime, this is *N. Lucasana*, Defr., var. *a*, Monogr. p. 125, pl. 7. fig. 7.

Var. γ , pl. 7. figs. *c-f*. A small, smooth, lenticular Nummulite ($3\frac{1}{2}$ lines in diameter), more convex on one face than on the other. In the section, fig. *e*, $6\frac{1}{2}$ whorls are seen, with the central cell large, and thirty-six chambers in the outer whorl (thirty-two on the fifth, and about the same number in the third whorl); chambers very like those of *N. Mamilla* and *N. lenticularis*, var. *a*, but more numerous.

MM. d'Archiac and Haime refer this to *N. Molli*, d'Arch., Monogr. p. 102, pl. 4. fig. 13.

Var. δ , pl. 7. fig. *g*. A small lenticular Nummulite, $3\frac{1}{2}$ lines in diameter, marked with twenty-four more or less curved or sinuous striæ, radiating from the periphery towards the centre of the face, but leaving a small clear umbonal area.

M. D'Orbigny collates this variety as identical with his *N. radiata*, For. Foss. Vien. p. 115; but we cannot coincide in this determination, though these varieties may belong to one species. According to MM. d'Archiac and Haime, this is *N. Biaritzensis*, d'Archiac, Monogr. p. 131, pl. 8. figs. 4-6.

Var. ϵ , pl. 7. fig. *h*. A small lenticular Nummulite, $3\frac{1}{2}$ lines in diameter, resembling var. δ , excepting that the interspaces between the radial lines are occupied with granules, mostly in single rows of from 4 to 7, but sometimes in double series towards the periphery.

This is *N. perforata* (Montf.), D'Orb., and accepted under that name by MM. d'Archiac and Haime, Monogr. p. 115, pl. 6. figs. 1-12.

These figures of five varieties of Nummulites, though boldly drawn and apparently with care, give us but little exact evidence of the real relationships of the originals. We have quoted the determinations arrived at by MM. d'Archiac and Haime, after considerable research; but, even with the aid of their painstaking and minute descriptions and their numerous and faithful drawings, we cannot readily follow them to their conclusions.

Nummulinae, like other *Foraminifera*, take such licence in their mode of growth, in the relative size and setting-on of the segments and their alar lobes, and in the exaggeration of the exposed septal lines and pillars by the, as it were, capricious growth of shell-matter, that it is difficult, even with the best-grown of these giants of the family, to determine where anything like specific limits can be marked out.

It appears to us that, in its style of growth, *Nummulina* is related to *Operculina*,—so closely, indeed, that, like *Assilina*, the latter sinks to the low grade of a subvarietal condition, there being no strict boundary between it and *Nummulina*, as we find abundantly proved by both recent and fossil specimens. Just so *Nonionina* loses itself in *Polystomella*.

The hundreds of indifferently described Nummulitic forms to be found in geological works were in 1853 reduced to order by the combined labours of M. le Vicomte d'Archiac and M. Jules Haime, and arranged as fifty-two species, grouped in six sections,—namely, 1. *Nummulinae laeves aut sublæves*; 2. *Reticulatae*; 3. *Subreticulatae*; 4. *Punctulatae*; 5. *Plicatae vel striatae*; 6. *Explanatae* (septa et spira plus minusve prominentes),—Nos. 1–5 forming the division characterized by “cloisons embrassantes, plus ou moins inclinées et arquées,” No. 6 being a division by itself, with “cloisons non embrassantes et presque droites.”

The group No. 1, “*laeves*,” have the alar or umbilical lobes attenuate (corresponding to the smallness of the segments) and extremely sinuous,—“filets cloisonnaires simples, très-sinueux.” This is the chief characteristic of the large, flat, smooth Nummulites forming the group, of which *N. complanata*, Lamarck, is the type. We should have preferred the term “*sinuatae*” or “*complanatae*” for the group. Groups No. 2 and No. 3, “*reticulatae*” and “*subreticulatae*,” are characterized by the inosculation of the “filets cloisonnaires” or alar lobes of sarcode proceeding laterally from the segments; they are so closely related, that we may regard them as one group, characterized by the net-like arrangement of the inosculating lobes, “réseau cloisonnaire,” and typified by *N. laevigata*, Lam. The “*punctulatae*” of group No. 4 are, we believe, artificially brought together: they belong part to group 1 and part to group 5, and in some cases have very close relations with groups 2 and 3. The feature referred to as characteristic in group No. 4 is the granulation of the surface; and, owing apparently to the strange mistake of the authors (formerly made also by Dr. Carpenter in his Memoir on Nummulites in the Quart. Journ. Geol. Soc. vol. vi.*) in regarding the subcrystalline columns seen in sections of Nummulites (that is, the septal walls and pillars) as calcareous

* Corrected by him in Phil. Trans. vol. cxlvi. p. 558, note.

infillings of funnel-shaped holes or pores, the nature of these granulations was misunderstood by MM. d'Archiac and Haime. In a Nummulite of any of the groups the septal lines exposed on the surfaces may be thickened, built up, or exaggerated by ridges or granules of hyaline shell-substance permeated with tortuous passages—part of the so-called “vascular system” of the shell; and these exogenous granules need not be confined to the septal lines, but may be planted in the interspaces, as in *Amphistegina* and other cognate forms, and will thus stand as lines and pillars of division to the alar lobes as the new segments are successively added. This is markedly the case in *N. scabra*, Lam., the granulated variety of *N. lævigata*, and indeed in numerous instances among *Nummulina* and their allies. In many Nummulites the granulate surface may be found at one period of growth, and the smooth at another; for, if a new segment or segments have been lately added, the surface will be far smoother than in the stage when the external increase of the septal lines and pillars only is going on.

The group No. 5, “plicatæ vel striatæ,” contains a great many varieties characterized by a simple radiate arrangement of the alar lobes, which are usually elongate triangular, straight or slightly curved, either falciform or sigmoid. These Nummulites are usually small, and are well typified by *Num. planulata*, Lamk. We should have preferred the term “radiatæ” for this group.

No. 6 is the Assiline group (“explanatæ”), in which the whole of the spire is apparent from the want of the alar lobes. *Assilina*, however, like *Operculina*, passes by insensible gradations into *Nummulina*, by the varying development of the lateral lobes or flaps.

There are individual specimens that tend to show a linking together of the “sinuate,” “reticulate,” and “radiate” groups; but for the present we propose to regard these as three *specific* groups, headed respectively by *Nummulina complanata*, *N. lævigata*, and *N. planulata*. The Assiline forms are probably related as varieties to the “radiate” and “sinuate” groups.

Having said thus much respecting the Nummulites generally, we return to Fichtel and Moll's illustrations, with the following remarks:—

N. Mamilla and *N. lenticularis*, var. α , do not present any indication of the superficial lobes; but, from the style of their chambers, they probably belong to the “radiate” group, and, for what we can see, are of the same species, the relative amount of convexity not being essentially distinctive.

N. lenticularis, var. β , may be the *N. Lucasana* (of the “radiate” group), as stated by MM. d'Archiac and Haime, but is

quite as like some of the granulate varieties of the "sinuate" group.

N. lenticularis, var. γ , is referred by MM. d'Archiac and Haime to the "reticulate" group, probably with justice, and to a new species. Nevertheless it much resembles their figures of *N. Tchihatcheffi* in every respect.

N. lenticularis, var. δ , is decidedly a "radiate" form, resembling *N. Ramondi*, *N. Guettardi*, *N. striata*, and others, even more than *N. Biaritzensis*, to which MM. d'Archiac and Haime refer it. The differences, however, are merely varietal.

N. lenticularis, var. ϵ , is far more like *N. Rouaulti* and *N. Lucasana* (of the "radiate" group) than *N. perforata* (of the "sinuate" group).

N. radiata, *N. venosa*, and their allies above described, are simple forms of the "radiate" group.

Nummulina, essentially symmetrical in all its varieties, is connected with the truly unsymmetrical species of Nautiloid Foraminifers by the unequal-sided *Amphistegina*, small varieties of which have a striking isomorphism with the Asterigerine varieties of *Rotalia Beccarii*—for instance, the *Asterigerina lobata* and *A. carinata* of D'Orbigny; but the Rotalian forms seldom hide their primordial cell in their successive folds, whilst this habit is constant in *Amphistegina*, however distorted it may become: thus this species never exposes its spire on both sides, like *Operculina*, nor on one side, as in *Polystomella macella* and the *Rotaliæ*. *Heterostegina* (a flattish Nummulitoid species with subdivided chambers) is in external form rather more like some *Operculinæ*, with the earlier portion lenticular, and with thin marginal chambers*, than an *Amphistegina*; and it bears the same relation to *Operculina* that *Orbiculina* does to *Peneroplis*; whilst *Cycloclypeus*, a species next beyond *Heterostegina* in development, is in this respect analogous to *Orbitolites*. See also Dr. Carpenter, Phil. Trans. 1856, vol. cxlvi. p. 565.

16. *Nautilus Calcar*. Page 69. Twelve varieties. Five varieties (α – ϵ): "Recent: Rimini shore, Adriatic. Fossil: Coroncina, near Sienna."

Var. α . Pl. 11. figs. a – c . Keeled, rowelled, ribbed, and un-

* The form here referred to, with its gently biconvex centre and thin edge, is the *Amphistegina Cumingii* of Dr. Carpenter, so fully described and illustrated in his last Monograph (read before the Royal Society, June 17, 1858, and published in the Phil. Trans. for 1859). We cannot agree with this talented author in placing this somewhat feebly developed Nummuline form in the genus *Amphistegina*. For our own part, we cannot, on any good physiological grounds, separate it from *Operculina complanata*, on the one hand, or *Nummulina planulata*, on the other, which latter we regard as the parental form of both.

bonate. A thick, well-developed *Cristellaria Calcar*: typical. See Annals N. H. 2 ser. vol. xix. p. 290; and ibid. 3 ser. vol. iii. p. 476.

Var. β . Pl. 11. figs. *d-f*. ("Planeus, Coneh. p. 85, pl. 1. fig. 12, STV, and fig. 13 *z, Z*; Soldani, Sagg. Orit. pl. 1. fig. *g, G*, Testaceogr. vol. i. pl. 33. fig. B.") Keeled, ribbed, and umbonate. *Cristellaria cultrata* of authors: a common well-developed variety.

Var. γ . Pl. 11. figs. *g-h*. Keeled, rowelled, bead-ribbed, and umbonate.

Var. δ . Pl. 11. figs. *i-k*. Keeled, rowelled, and bead-ribbed. γ and δ are varieties of *C. Calcar* ornamented with granulated septal lines.

Var. ϵ . Pl. 12. figs. *a-c*. ("Soldani, Sagg. oritt. p. 98, pl. 1. fig. 6 J; Testaceogr. vol. i. pl. 59. figs. *q q, r r*.") Keeled, rowelled, with irregular spikes, ribbed, umbonate; surface granulate and chambers narrow. A fine variety of *C. Calcar*, with narrow falciform chambers.

Var. ζ . Pl. 12. figs. *d-f*. "Fossil: Ripalta, near S. Quirico, in the Sienese." Keeled, ribbed, umbonate; last few chambers distorted. *C. cultrata*: a modified individual.

Three varieties (η - ι). "Recent: Adriatic and Mediterranean. Fossil: Coroneina." Var. η . Pl. 12. figs. *g, h*. ("Planeus, Coneh. p. 12, pl. 1. fig. 3 H.") Keelless, ribbed, umbonate. The most common variety of *C. Calcar* in its less-developed state. The same as *C. rotulata*, *Robulina simplex*, &c.

Var. θ . Pl. 12. figs. *i, k*. Keelless, slightly rowelled, ribbed, and umbonate. Like the last, but rowelled.

Var. ι . Pl. 13. figs. *a, b*. Keeled, slightly rowelled, bead-ribbed, the granulate septal lines meeting at the umbo. An ornamented variety like vars. γ and δ , but smaller.

Var. κ . Pl. 13. figs. *c, d*. "Recent: Mediterranean." Keel slight, with some teeth; ribs faint; no umbo; chambers narrow. A variety of *C. Calcar*, faintly developed as to its several features.

Var. λ . Pl. 13. figs. *e-g*. "Fossil: Coroneina." Slightly keeled, faintly ribbed, umbonate; chambers large. A variety of *C. Calcar*, with large-sized chambers.

Var. μ . Pl. 13. figs. *h, i* (*k, l*, section). "Recent: Mediterranean. Fossil: Coroneina." Sharply rowelled, faintly ribbed, largely umbonate. The exogenous shell-substance in this variety of *C. Calcar* forms long sharp keel-teeth, and a large umbo.

Cristellaria Calcar, of a symmetrical but limited growth, occurs early in the Secondary deposits, and is often abundant in the clays of the Upper Trias, Lias, Oolites, Gault, and Chalk.

In the Tertiaries it is also abundant, and frequently attains a larger size, and puts on a bolder form of growth. In the recent state it is world-wide,—localities for large specimens being the Canaries, Mediterranean (especially the Adriatic), Norway coast, and the Abrolhos Bank. Bailey has figured it of a large size from the coasts of the United States.

17. *Nautilus papillosus*. Page 82, pl. 14. figs. *a-c*. “Recent: Adriatic.” An elegant variety of *Cristellaria Calcar*, with a small keel and beaded septal lines. It is thick, and has many chambers.

18. *Nautilus Vortex*. Page 33, pl. 2. figs. *d-i*. “Soldani, Sagg. Oritt. p. 99, pl. 1. fig. 12; Testaceogr. vol. i. p. 66, pl. 59. fig. *i t*.” “Fossil: Coroneina.” This is a keelless, thick variety of *Cristellaria Calcar*; it has very narrow and much-curved chambers, the septal lines taking a long, curved sweep to reach the margin. There are many gradual intermediate forms between this and the type. It is not unfrequent in clays of the Mediterranean, at about the depth of 90 fathoms; and it occurs fossil in the Tertiary clays of Tuscany, Vienna, and Malaga.

D’Orbigny has given two figures of this variety: that of his *Robulina orbicularis*, Annales Sc. Nat. vol. vii. p. 288, No. 2. pl. 6. figs. 8, 9; and that of his *R. Imperatoria*, For. Foss. Vien. p. 104, pl. 5. figs. 5, 6. The former differs from *Cristellaria Vortex* in having a slight keel, in not being quite so thick, and in being somewhat umbonate. *R. Imperatoria*, having the same amount of keel as *R. orbicularis*, is less gibbous, but more distinctly umbonate than the latter. These slight and almost insensible degrees of modification render the three shells here referred to notable examples of the gradual passage so often recognizable between varietal forms of species. The roundness and plumpness of *Cristellaria Vortex* is modified to the lenticular and comparatively lean *C. Imperatoria*, having markedly contracted chambers (the narrowest of any *Cristellaria*) and a pouting aperture, which is lost in the greater fulness of the chambers of *C. Vortex* and *C. orbicularis*. Full-sized and entire-keeled specimens of *C. Vortex*, supplying still further intermedia, are figured by Soldani.

19. *Nautilus costatus*. Page 47, pl. 4. figs. *g, h*. “Recent: Mediterranean, Coast of Africa.” A *Cristellaria*, more or less keeled; the keel is somewhat toothed; the septal lines are raised or limbate,—a character which, however, is absent in D’Orbigny’s figured specimen of a similar variety from the Tertiary beds of Vienna (*Robulina Ariminensis*, For. Foss. Vien. pl. 4. figs. 8, 9); the chamber-walls are regularly marked with numerous ribs at right angles to the septal lines. In this variety of *C. Calcar* (which is not of common occurrence, but sometimes met with in

deposits rich in *Cristellaria*) we have the link with the Marginuline variety of *Nodosaria Raphanus*, especially in the Viennese specimen, which is narrow-chambered, pinched, and umbilicate, like the erozier-part of a *Marginulina*. This linking is not only shown by the form, the aperture, and the general structure of the shell, but markedly in the style of ornament. The ornamentation of ribs is highly characteristic of the Nodosarine group. In *Nodosaria* the riblets are often fully and symmetrically developed; in some *Marginulina* the rib on the convex border surpasses its fellows; in *Cristellaria* it is often the only remnant of these ribs; but in some varieties, as in *Robulina echinata*, D'Orb., *R. ornata*, D'Orb., and especially in *R. Ariminnensis* and Fichtel's *Nautilus costatus*, the rib-ornament still bears evidence of the relationship mutually borne by these diversely modified forms. Hence one of the grounds for the foundation of the comprehensive genus *Nodosarina**, intended by us to embrace the *Nodosaria*, *Cristellaria*, and all the intermediate and associated varieties. Indeed, we see as yet no essential characters in this protean group whereby more than one real species can be established, although we have examined thousands of forms, not to say individuals, from the Permian, Triassic, Liassic, Oolitic, Cretaceous, and Tertiary deposits, as well as from deep and shallow seas of all parts of the world.

20. *Nautilus acut-auricularis*. Page 102, pl. 18. figs. *g-i*. "Recent: zoophytic concretions, Mediterranean." A subglobose or ovoid *Cristellaria*, with numerous smooth, narrow, flush chambers, slightly keeled. This is a variety intermediate between *C. Calcar* and Defrance's *Saracenaria Italica*. It is also nearly related to *C. arcuata*, D'Orb. (For. Foss. Vien. pl. 3. figs. 34-36). This appears to be a rather rare and small form. Fichtel and Moll's reference to Soldani, Testaceogr. vol. i. p. 61, pl. 49. fig. *x*, for this form, is correct.

21. *Nautilus Crepidula*. Page 107, pl. 19. figs. *g-i*. "Recent: Leghorn coast." A delicate, elongate, Marginuline, flattened *Cristellaria*. This variety, which by innumerable linkings passes into *C. Calcar*, is so readily modified by external conditions as perhaps not to be represented by any two perfectly similar individuals. D'Orbigny's *C. cymboides* (For. Foss. Vien. pl. 3. figs. 30, 31) is almost an exact counterpart of Fichtel's figure; but in the former the coil is more open. *C. compressa*, D'Orb. (*loc. cit.* figs. 32, 33), and *C. lanceolata*, D'Orb. (*l. c.* figs. 41, 42), as well as Montfort's "Astacole crepidule," which is Blainville's and Defrance's "Crepiduline astacole" (Diet. Se. nat. pl. 19. fig. 8), are similar attenuate, but keeled, varieties of *Cristellaria Calcar*.

* Annals, 1859, iii. p. 477.

Cristellaria Crepidula runs insensibly into *C. Cassis* on one hand, and on the other into the Planularian section of the *Vaginulinæ*. It is common wherever *Cristellariæ* are abundant, whether in the fossil or recent state. The specimen figured by Soldani (Testaceogr. vol. i. p. 64, pl. 58. fig. *bb*) is very similar to *N. Crepidula*, as Fichtel and Moll supposed.

22. *Nautilus Cassis*. Page 95. Five varieties. "Fossil: Coroncina."

a. Pl. 17. figs. *a-d*. Plancus, Conch. p. 120, pl. 1. fig. 11 Q R.

β. Pl. 17. figs. *e-g*. Soldani, Orit. p. 97, pl. 1. fig. 1 A B C.

γ. Pl. 17. figs. *h, i*.

δ. Pl. 17. figs. *k, l*. Soldani, Testaceogr. vol. i. p. 63, pl. 55. fig. A.

ε. Pl. 18. figs. *a-c*.

We have here some modifications of a varietal form of *Cristellaria*, discoidal and foliaceous, apt to be ornamented by clear granules at the centre and along the septal lines, and to expand itself into a broad and serrate keel.

Individuals of this variety are often pre-eminent among *Cristellariæ* for their size and elegance. Their sinuous and, as it were, loosely-set chambers, their flatness, and the irregular position of the aperture, remove them but a little way from the typical *C. Calcar*. In the var. *ε* the aperture is so nearly central that the chambers grow saddle-shaped, and present us with the essential characteristic of *Flabellina*. Hence the removal of another supposed "generic" limit,—nay, of a "specific" boundary.

Cristellariæ of this shape and size occur in the Italian Subapennine Tertiaries, and also at Malaga in Spain. Individuals of smaller growth abound in some Secondary and Tertiary deposits, and also in recent seas. In the muds dredged off the Abrolhos Bank, in about 30 fathoms water*, we have similar *Cristellariæ*, almost rivalling the Subapennine specimens.

Besides the references to Soldani and Plancus above noted, Fichtel and Moll refer with justice to Soldani (Testaceogr. vol. i. p. 63, pl. 55. figs. A-G, and pl. 56. figs. H-N) for figures of various forms of *Cristellaria Cassis*.

23. *Nautilus Galea*. Page 100, pl. 18. figs. *d-f*. "Fossil: Coroncina." This is a fine, outspread, extremely flattened, smooth, and broad-keeled *Cristellaria Cassis*, with very widely transverse chambers, the inner extremities of which stretch beyond the spire. In this feature we have an interesting isomorphism, if we may so term it, with other and not related generic forms. This individual, with its attempt at cycloid growth, reminds us of the *Peneroplis planatus*, in its broadest forms, out-

* By Capt. Richards, H.M.S. 'Plumper.'

grown from their short, thick, Dendritine type; and also of that peculiar variety of *Vertebralina striata* in which the later chambers curve round and embrace the earlier spiral portion (*Renuclites opercularis*); nor is the mode of growth essentially different in *Orbiculina*, which shows this tendency in *O. adunca* and its varieties, and becomes perfectly eyelieal in some individuals,—a feature which is the typical character in *Orbitolites*.

24. *Nautilus Spengleri*. Five varieties. Page 84. Fichtel and Moll make the following appropriate references:—Linn. Syst. Nat. xiii. Gmel. p. 3371. no. 10: Spengler, Schrift. dän. Gesellseh. Kopenh. vol. i. p. 373, pl. 2. fig. 9 *a b c*: Schröter, Einleit. Coneh.-Kennt. vol. i. p. 756; Neue Literat. u. Beytr. z. Naturg. vol. i. p. 309, pl. 1. figs. 3–6; Schreibers, Coneh. Kenntn. vol. i. p. 5. no. 10.

a. Pl. 14. figs. *d–f*.

β. Pl. 14. figs. *g–i*.

γ. Pl. 15. figs. *a–c*.

δ. Pl. 15. figs. *d–f*.

ε. Pl. 15. figs. *g, h*.

Pl. 15. figs. *i, k*, sections.

“Recent: from sand in a *Buccinum cassideum* (Gmelin) from the East Indian Sea; and from the Red Sea.”

This belongs to the Rotalian group; the shell is unsymmetrical, like the other *Rotaliæ*, and is marked by an extensive growth of exogenous granular shell-matter. This luxuriant shell-growth is shown also in the very variable rays or spines, which, commencing near the umbilicus in the septal interspaces, advance outwards often to a considerable distance (equal even to the width of the shell) from the periphery. The cell-growth also often becomes wild, the later chambers irregular and heaped, being outspread on the granulated surface of the upper side. The rough and prickly surface is a very constant character in this *Calcarina*, although some very minute forms show it only in an umbilical boss and a prickle on the periphery of each chamber. What seems to be a large aperture in these figures arises from the fracture of the newest chamber, which is, until well coated with exogenous matter, extremely thin. In well-preserved specimens of the typical forms we find that the real aperture, which is essentially a slit, as in the true *Rotaliæ*, becomes bridged over by delicate bars of shell-matter. *Calcarina* is a subgenus of *Rotalia*, characterized by its excessively spinous coating and eribriform aperture. In its spines, in the copiousness of its exogenous matter (which is tubuliferous), and in its generally eribriform aperture, it affords us an analogy to the *Polystomella crispa*; whilst other *Rotaliæ* have on their part a corresponding analogy to the smooth-shelled *Nummulina* and *Amphistegina*.

Rotalia Beccarii, often prickly and even spinous, is the linking form between *Calcarina Spengleri* and the ordinary *Rotalia*, and at the same time is rich in varieties isomorphous with many conditions of *Polystomella*.

Rotalia (Calcarina) Spengleri is found in all warm seas. This is the *Siderolites calcitrapoides* of Lamarck, and *Siderolina lævigata*, D'Orb., both from Maestricht. The latter is Fichtel and Moll's var. ϵ .

25. *Nautilus repandus*. Page 35, pl. 3. figs. *a-d*. "Recent : zoophytic concretions, Mediterranean."

This is a true *Rotalia*, and is a typical form of a large number of varieties which have their cells numerous but very variable in their convexity,—so much so that they often produce a much more expanded shell than the one here figured, and even irregular in growth ; on the other hand, they may become contracted and few-celled, forming a thick conical shell. The aperture is usually a large slit at the base of the last chamber ; but in some of the more compact forms, in which the chamber-walls are flush, the aperture passes into the condition of a notch : hence the forms of aperture once supposed to be respectively characteristic of *Rosalina* and *Rotalia* are in this species shown to be non-essential. The specimen figured by Fichtel and Moll is probably not very well drawn ; for in specimens of similar size and form we find the spire better marked.

A flatness of the septal face is a very usual feature in this species.

This is a world-wide species in its typical condition ; and its many varieties are equally abundant and common. In deep water this species is represented by the variety *Rotalia Menardii*, D'Orb., which is flattish, limbate, and granular, and has for companions the contracted varieties *R. Micheliniana*, D'Orb., *R. crassa*, D'Orb., and *R. nitida*, Reuss, together with intermediate forms. In shallower water, especially on muddy bottoms, we find large, smooth, flush-chambered and more or less limbate forms, such as *R. Partschiana*, D'Orb., and *R. Schreibersii*, D'Orb. ; but the former of these is often found at great depths.

In the Laminarian zone this species often takes on an irregularity of growth, many of the latter chambers elongating themselves without septa. Thus (becoming almost as simple as *Spirillina vivipara*, Ehrenberg) it becomes the *Planorbulina vermiculata*, D'Orb., Ann. Sc. Nat. vol. vii. p. 280.

The two varieties of this species represented by D'Orbigny in his 'Modèles,' No. 12 (*R. punctulata*, D'Orb.) and No. 10 (*R. pulchella*, D'Orb., which is the same as *R. Caribbæa*, D'Orb.), must be placed very close to the typical *R. repanda* (which, indeed, is intermediate between these two).

In this species the shell is for the most part very finely pored; but when the septal face is much flattened, or the shell takes on a wild growth, a number of large holes give a punched aspect to the septum; and even, in the vermiculate forms, the whole of the under surface of the shell is thus coarsely pertused.

Varieties of this species occur fossil as far back as the Upper Trias, in nearly all the clays of the Oolites, in the Gault and Chalk, and throughout the Tertiaries. It may be found in all seas; and we have it from the Tropics, brought up from 2700 fathoms (Capt. Pullen's soundings).

26. *Nautilus sinuatus*. Page 65, pl. 10. figs. *a-d*. "Fossil: San Quirico in the Siennese."

This is a small-sized variety of the *Rotalia repanda*. It is more margined and flattened; it is limbate on some of the septal lines. The early part of the spire is hidden here by granules. This ornament is seen in other varieties on the upper and occasionally on the under surface. The different degrees of ornament produced by exogenous shell-growth in the margins, in limination, and in granulation, scarcely permit us to find two specimens alike, to say nothing of the variability as to the size and thickness of the shell and the number of chambers. Still the species has a habit of its own, with a peculiar setting-on of the chambers, and style of ornament, which help us to see a specific relationship between forms at first sight very different, and at the same time to recognize limiting distinctions between the most aberrant forms and their isomorphs belonging to other species.

D'Orbigny's Model No. 71 (*Rotalia pulchella*, D'Orb.) is one of the nearest to this variety (*R. sinuata*), which is world-wide.

27. *Nautilus Auricula*. Page 108. Var. *a*. pl. 20. figs. *a-c*. "Soldani, Testaceogr. vol. i. pl. 50. fig. Y." "Fossil: Coronica."

Var. *β*. pl. 20. figs. *d-f*. "Recent: zoophytic concretions, Mediterranean."

These are delicate oblong varieties of *Rotalia repanda*, with rapidly increasing chambers. They bear the same relation to their type as *Nonionina Scapha* does to *Nonionina asterizans* and *Polystomella crispa*.

The intermediate links between the typical *R. repanda* and *R. Auricula* are found in the less oblong forms common in some of the Subapennine Tertiary beds, such as those of Palermo and Turin: in these a part only of the septal face is flattened and drilled with very coarse foramina, the rest remaining slightly gibbous and finely perforated; whilst in many other varieties of

R. repanda the septal face is uniformly flat and pertused, for instance *R. Caribbæa*, D'Orb., and *R. pulchella*, D'Orb. In *R. Auricula* and its immediate congeners the whole septal face is more or less convex and delicately porous.

Some of these oblong varieties have been (as Professor Williamson has already noticed) erroneously grouped under the genus *Valvulina* by D'Orbigny; such as "*V. æqualis*," "*V. oblonga*," and "*V. excavata*."

In var. *a*, the outline is more entire, and the chambers less vesicular than in var. *β*. These belong to a very variable group of small elongate varieties of *R. repanda*. Var. *a* is intermediate between *R. Hauerii*, D'Orb. (For. Foss. Vien. pl. 7. figs. 22-24) and *R. Brongniartii*, D'Orb. (*op. cit.* pl. 8. figs. 22-24). Var. *β* approaches very closely to Williamson's *Rotalia oblonga* (Monogr. pl. 4. figs. 98-100); the latter, which is larger but less gibbous than var. *β*, attains its finest development in the English Channel and the Bay of Biscay, at from 50 to 70 fathoms; but similar varieties, though generally smaller, are to be met with in nearly every Foraminifer-bearing sea-sand or mud, at variable depths, and are rather common in almost all Tertiary deposits.

28. *Nautilus farctus*. Page 64, pl. 9. figs. *g-i*. "Fossil: Coroncina, near Sienna, Tuscany."

The shell here figured is essentially a plano-convex *Rotalia*; but in the further developments which varieties of this species exhibit we have characters presented that make it very convenient to divide the forms of this group (as well as those of another *Planorbulina*, typified by *Rosalina Poeyi*, D'Orb.) from the ordinary *Rotaliæ*. For this subdivision the well-known name *Planorbulina* is retained, which was used generically by D'Orbigny for the outspread many-celled varieties of *Nautilus farctus**. The common *Truncatulina lobatula*, Walker, is a simple form of this type, arrested, as it were, in its development; and many of the little so-called *Rosalinæ*, *Rotalinæ*, *Anomalinæ*, and *Planulinæ*, are equally simple dwarf forms; their relative vesicularity or complanation being due to accidental style of growth and place of attachment, whether it be sea-weed, rough or smooth shell, or other substance. The depth of water, also, and character of the sea-bottom affect the growth of these very variable shells. Every collector knows the *T. lobatula*, with its white plano-convex shell, crenulate outline, slit-like aperture, and coarse perforations. Similar features, modified, characterize *Nautilus farctus*; this, however, is differentiated by some amount of limbation on the convex face, and by the greater height of the

* In his genus *Planorbulina*, D'Orbigny placed also some Spirilline varieties of *Rotalia repanda* (such as *Pl. vermiculata*).

chambers. *Planorbulina nitida*, D'Orb. (Modèles, No. 78), is a similar form to the last mentioned, not markedly limbate, and having more chambers. *Pl. Mediterraneensis*, D'Orb. (Ann. Sc. N. vol. vii. p. 280, pl. 5. figs. 4-6; and Modèles, No. 79), presents a further developmental step in the growth of these instructive varieties; for here we find the same morphological plan, with an increase of chambers, in a delicate and scale-like shell. In *Pl. vulgaris*, D'Orb. (For. Cuba, pl. 6. figs. 11-15), we have a coarser and somewhat biconvex shell, with a wilder mode of growth. The chambers become baggy and divergent, and present supernumerary lipped apertures. The more irregularly constructed shells of *Pl. vulgaris*, whether heaped into a little racemous mass, or ringing the smooth stems of sea-weeds, have been denominated *Acervulinae* by Schultze. Arrested conditions of this biconvex variety constitute the *Anomalinae* of D'Orbigny: amongst the thickest and most symmetrical of these is our *A. coronata* (Ann. Nat. Hist. ser. 2. vol. xix. p. 294, pl. 10. figs. 15, 16); whilst the thinnest and most outspread is the *A. Rotula*, D'Orb. (For. Foss. Vien. pl. 10. figs. 10-12). This last-named variety, elegant in its delicate symmetry, is subject, among other modifications, to a variable exogenous overgrowth on its septal lines, as, for instance, *Rosalina Edwardsiana*, D'Orb. For. Cuba, pl. 6. figs. 8-10, and *Truncatulina ornata*, D'Orb. For. de l'Amér. Mérid. pl. 6. figs. 7-9; and thus it insensibly loses itself in the subsymmetrical and strongly limbate *Planulina Ariminensis*, D'Orb. (Ann. Sc. Nat. vol. vii. p. 280, pl. 5. figs. 1-3, Modèles, No. 49.) In our already quoted paper on the Rhizopods of the Norway coast, we have erroneously placed *Pl. Ariminensis* among the synonyms of *Operculina complanata*, misled by its extreme similarity of shape.

Soldani has devoted many plates in his 'Testaceographia' to figures of the very protean *Truncatulina variabilis*, D'Orb., a Mediterranean form exactly intermediate between the tropical *Planorbulina vulgaris* and *Nautilus farctus*, which we find recent in the Mediterranean and other seas. This noble work also affords numerous striking illustrations of the other varietal forms, differing in their extremes, yet blending by gentle gradations.

Nautilus farctus is a Planorbuline *Rotalia*, and is the type of the species comprehending the above-mentioned and many other varieties. Like *Rotalia repanda*, it represents the medium between extreme conditions; its discoidal growth and its high and well stuffed-out chambers give it good title to its name and systematic place. Whilst arrested, as compared with some of the extravagantly grown forms, it is much better developed than many of the varieties enumerated, presents indications of all its essential specific features, and keeps its subgeneric characters

better than the trochiform varieties, some of which become, as it were, isomorphs of *Rotalia* proper, others of *Nonionina*.

29. *Nautilus tuberosus*. Page 111, pl. 20. figs. *g-k*. "Fossil: *Coroncina*."

This is a variety of *Planorbulina farcta*, with many chambers irregularly set on, and mostly narrow. This *Pl. tuberosa* has the biconvex form which chiefly characterizes D'Orbigny's *Anomalina*, and is intermediate to his *A. Badenensis* and *A. Austriaca*. This tuberoso variety may be said either to represent an early stage of *Planorbulina vulgaris*, or to be a neatly growing and nearly symmetrical modification of *Truncatulina variabilis*. Like *P. farcta*, this variety is very common in the Mediterranean and other warm seas, and occurs in Tertiary deposits.

30. *Nautilus planatus*. Page 91. Three varieties. "Recent: Leghorn coast, Tuscany."

Var. *α*. Pl. 16. figs. *a-c* (*i*, section). "Schröter, Neue Literat. d. Naturgesch. vol. i. p. 314, pl. 1. fig. 7."

Var. *β*. Pl. 16. figs. *d-f*.

Var. *γ*. Pl. 16. figs. *g, h*.

This is "le Pénérople aumusse" (the *Peneroplis planatus*) of Denys de Montfort, and is a distinctly specific type of one of the opake-shelled Foraminifers. Commencing with a primordial double chamber, like that of the *Miliola*, *Orbiculina*, and *Orbitolites*, it soon takes on a Nautiloid growth; the aperture, at first single, margined, and irregular, soon becomes more irregularly trilobate in the successively enlarging triangular septal faces (as in *Dendritina*, where it is arborescent); in a further stage of the shell, the newer chambers are flat, narrow, and transversely long, spreading out with widening curve,—keeping a Nautiloid outline, as in var. *α*; becoming auricular or bonnet-shaped, as in var. *β*; or showing some modifications of the above, arising from an irregular periodicity of growth, as in var. *γ*. In other forms, the shell grows on until the newest chambers extend in their curvature far back, even to three-fourths of a circle, as if they would take on a cyclical growth, such as is normal in *Orbiculina* and *Orbitolites*. In the broad, complanate, typical varieties, the septal face is necessarily very long and narrow, and is perforated by one or more rows of roundish or hourglass-shaped, thickly margined passages, subtubular and more or less ecto-ento-solcian. This condition is attained by the gradual lincation and subdivision of the lobulate and dendritine aperture. These broad forms are from the seaweed-belt of the warmer seas; but in somewhat deeper water they are gradually replaced by smaller and contracted varieties, in which the spiral portion is small and nautiloid, followed by a long series of either compressed or cylindrical joint-like cells, presenting altogether an elegant crozier-

like outline. In these, as in *Dendritina*, the aperture is single and lobulate. The name *Spirolina* has been given to these attenuated varieties. Other Foraminifers, especially some varieties of *Lituolæ*, presenting similar elongate shells with a spiral commencement, have been included under the same name, thus adding to a confusion of nomenclature.

Peneroplis is characteristically a creature of warm climate, and does not exist in the North Atlantic, German Ocean, English Channel, and other north temperate seas. We fully agree with Prof. Williamson that the few specimens which he mentions and figures in his 'Monograph' are strangers to the British Fauna.

Since writing the above, we have been favoured with the valuable and beautifully elaborate memoir on *Peneroplis*, *Operculina*, &c., by Dr. Carpenter (Phil. Transact. 1859), and must refer our readers to that as a source of correct and detailed information respecting the forms under notice, the structure and tissue of which are therein described in a masterly manner; whilst they are most elegantly and copiously illustrated by some of George West's best lithographs.

Peneroplis planatus is well figured by Ehrenberg, both as to its shell and its sarcode, in the 'Abhandl. Akad. Berlin,' 1838 (1839), pl. 2. figs. *a-d*; and its Spiroline forms, under the name of "*Coscinospira* (*Spirolina*) *Hemprichii*," are also well delineated on the same plate, figs. *a, b*.

31. *Nautilus aduncus*. Page 115, pl. 23. figs. *a-e*. "Recent: Red Sea."

This elegant Foraminifer, now known by the generic name *Orbiculina*, which was instituted by Lamarck, has been of late years fully described and illustrated by Prof. Williamson (Trans. Microscop. Soc. 1st ser. vol. iii. p. 120) and by Dr. Carpenter (Phil. Trans. 1856, vol. cxlvi. p. 547, pl. 28. figs. 1-22, and pl. 29. figs. 1-3). To the latter we are indebted not only for a succinct history of this species, and for a clear exposition of its structural characters, but also for the bold and masterly exposition of the true philosophical principles on which the zoological relations of this and other species of Foraminifera are to be studied. This ear-shaped *Orbiculina adunca* is doubtless the typical form, as compared with the further and extreme step in development by the increase and extension of the peripheral chambers, which produces suborbicular discoidal shells, bringing *Orbiculina* into close parallelism with the typically cyclical *Orbitolites*. The cyclical forms of *Orbiculina* may be often the result of continued growth of individuals under favourable circumstances; but frequently small starved forms quickly take on the cyclical condition, leaving the young sublenticular stage with-

out passing through the aduncal. Therefore, in a sense, these may be regarded as varietics.

Ehrenberg has given good figures of *Orb. adunca* in Abhand. Akad. Berlin, 1838 (1839), pl. 3. figs. 1a-1d.

32. *Nautilus Orbiculus*. Page 112, pl. 21. figs. a-d. "Recent : Leghorn*."

This is the thick orbicular, or subnautiloid condition of *Orbiculina adunca*, which small and young specimens almost uniformly exhibit, though some are flatter. The apertural surface is as yet very contracted.

33. *Nautilus angulatus*. Page 113, pl. 22. figs. a-e. "Recent : Red Sea."

In this stage, *Orbiculina adunca*, still sublenticular, puts on a broader and angular septal face, showing an increase in the space for pseudopodial apertures, which will extend along the marginal area, in the adult shell, for three-fourths of a circle, and around the entire periphery in the cyclical varietics.

The neat and uniform subdivision of the chambers in *Orbiculina* is shown in the three sections given by Fichtel and Moll. We may remark that, not unfrequently, feebly-developed Peneopliform varietics, as well as good-sized Adunciform specimens, occur in which the long narrow chambers are at times simple and undivided, being occupied by transversely elongate lobes of sarcodæ, instead of numerous minute subcubical blocks.

Orbiculina has its home, as it were, in the West Indies; it occurs also in the Red Sea, the Indian Ocean, and on many coasts of the warmer seas.

34. *Nautilus Melo*. Two varietics. Page 118. "Fossil : Brunn in Austria, Kroisbach in Hungary, and other places in Austria and Transylvania."

Var. α . pl. 24. figs. a-f.

Var. β . pl. 24. figs. g, h.

This is an *Alveolina*, an opaque-shelled Foraminifer, which, in its close relation to *Orbiculina* or *Orbitolites*, may be said to represent a small thick *Orbiculina* drawn out transversely at its umbilici, and thus bears the same relation to its congeners that *Fusulina* does to *Nonionina*.

Dr. Carpenter (*op. cit.* p. 552, pl. 28. figs. 23, 24, and pl. 29. figs. 4-9) has so well described the structure of a recent *Alveolina* illustrative of the species to which var. α (prolate spheroid)

* This locality appears strange to us, as we have not, after much seeking, found this shell living in the Mediterranean. Dr. Carpenter, however, quotes it from the *Ægean Sea*; it occurs fossil in a white limestone at Corfu; and D'Orbigny figures a minute form (*O. Rotella*) from the Vienna Tertiaries.

must be referred as a melon-shaped, and var. β (oblate spheroid) as a spheroidal variety, that we need merely refer to his memoir, where a historical account of the species is also given. The oldest specific name on record for *Alveolina* is *A. Melo*, which may well pass as the type. *A. Boscii* is a well-developed form, and *A. Quoyii* is a fine elongate variety, rather elubbed at the ends, which attains a large size ($\frac{2}{3}$ inch in length) in Fiji, and is also large in Australia, where, with it, *Orbitolites* arrives at its greatest development, — a similar association to that obtaining in the Eocene deposit of Grignon. In India, Egypt, Austria, Spain, and elsewhere, *Alveolinae* occur fossil of many sizes, and of various shapes, from that of a shot to a spindle, or from that of a melon to a cucumber. They abound in rocks of the Nummulitic period. The largest we have seen was collected in Persia by the late Mr. W. K. Loftus, and is 3 inches long, and $1\frac{1}{2}$ inch in diameter !

Table of the Species and Varieties of Foraminifera figured in Fichtel and Moll's 'Testacea Microscopica.'

Fichtel and Moll's 'Testacea Microscopica.'			Specific and Varietal Names, after Fichtel and Moll.	Numbers of Reference.
Page.	Platc.	Fig.		
10	1	<i>a-c</i>	Argonauta Cornu *	
31	1	<i>a-c</i>	Nonionina pompilioides	3
33	..	<i>d-i</i>	Cristellaria Vortex	18
35	3	<i>a-d</i>	Rotalia repanda	25
37	..	<i>e-h</i>	Nonionina asterizans	1
38	4	<i>a-c</i>	Nonionina incrassata	2
40	..	<i>d-f</i>	Polystomella crispa, Linn.	10
47	..	<i>g-i</i>	Cristellaria costata	19
40	5	<i>a, b</i>	Polystomella crispa, Linn. (Sections)	10
49	..	<i>c-e</i>	Polystomella strigillata, α	9
..	..	<i>f, g</i>	————— β	9
51	..	<i>h-k</i>	Polystomella craticulata	11
53	6	<i>a-d</i>	Nummulina Mamilla	14
55	..	<i>e-h</i>	Nummulina lenticularis, α	15
..	7	<i>a, b</i>	————— β	15
..	..	<i>c-f</i>	————— γ	15
..	..	<i>g</i>	————— δ	15
..	..	<i>h</i>	————— ϵ	15

* This is the *Lippistes Cornu* of Montfort, and probably the *Separatista Grayi* of Adams.

TABLE—continued.

Fichtel and Moll's 'Testacea Microscopica.'			Specific and Varietal Names, after Fichtel and Moll.	Numbers of Reference.
Page.	Plate.	Fig.		
58	8	<i>a-d</i>	<i>Nummulina radiata</i>	12
59	..	<i>e-h</i>	<i>Nummulina venosa</i>	13
61	9	<i>a-c</i>	<i>Polystomella striatopunctata</i>	6
62	..	<i>d-f</i>	<i>Polystomella ambigua</i>	7
64	..	<i>g-i</i>	<i>Planorbulina faretta</i>	28
65	10	<i>a-d</i>	<i>Rotalia sinuata</i>	26
66	..	<i>e-g</i>	<i>Polystomella macella</i> , α	8
..	..	<i>h-k</i>	— — — — — β	8
69	11	<i>a-c</i>	<i>Cristellaria Calcar</i> , <i>Linn.</i> α	16
..	..	<i>d-f</i>	— — — — — β	16
..	..	<i>g, h</i>	— — — — — γ	16
..	..	<i>i, k</i>	— — — — — δ	16
..	12	<i>a-c</i>	— — — — — ϵ	16
..	..	<i>d-f</i>	— — — — — ζ	16
..	..	<i>g, h</i>	— — — — — η	16
..	..	<i>i, k</i>	— — — — — θ	16
..	13	<i>a, b</i>	— — — — — ι	16
..	..	<i>c, d</i>	— — — — — κ	16
..	..	<i>e, f, g</i>	— — — — — λ	16
..	..	<i>h, i</i>	— — — — — μ	16
..	..	<i>k, l</i>	— — — — — Sections	16
82	14	<i>a-c</i>	<i>Cristellaria papillosa</i>	17
84	..	<i>d-f</i>	<i>Calcarina Spengleri</i> , <i>Gm.</i> , α	24
..	..	<i>g-i</i>	— — — — — β	24
..	15	<i>a-c</i>	— — — — — γ	24
..	..	<i>d-f</i>	— — — — — δ	24
..	..	<i>g, h</i>	— — — — — ϵ	24
..	..	<i>i, k</i>	— — — — — Sections	24
91	16	<i>a-c</i>	<i>Peneroplis planatus</i> , α	30
..	..	<i>d-f</i>	— — — — — β	30
..	..	<i>g, h</i>	— — — — — γ	30
..	..	<i>i</i>	— — — — — Section	30
95	17	<i>a-d</i>	<i>Cristellaria Cassis</i> , α	22
..	..	<i>e-g</i>	— — — — — β	22
..	..	<i>h, i</i>	— — — — — γ	22
..	..	<i>k, l</i>	— — — — — δ	22
..	18	<i>a-c</i>	— — — — — ϵ	22
100	..	<i>d-f</i>	<i>Cristellaria Galea</i>	23
102	..	<i>g-i</i>	<i>Cristellaria acutauricularis</i>	20
103	19	<i>a-c</i>	<i>Nonionina Faba</i>	5
105	..	<i>d-f</i>	<i>Nonionina Scapha</i>	4
107	..	<i>g-i</i>	<i>Cristellaria Crepidula</i>	21
108	20	<i>a-c</i>	<i>Rotalia Auricula</i> , α	27
..	..	<i>d-f</i>	— — — — — β	27
111	..	<i>g-k</i>	<i>Planorbulina tuberosa</i>	29
112	21	<i>a-d</i>	<i>Orbiculina Orbiculus</i>	32
113	22	<i>a-e</i>	<i>Orbiculina angulata</i>	33
115	23	<i>a-e</i>	<i>Orbiculina adunca</i>	31
118	24	<i>a-f</i>	<i>Alveolina Melo</i> , α	34
..	..	<i>g, h</i>	— — — — — β	34